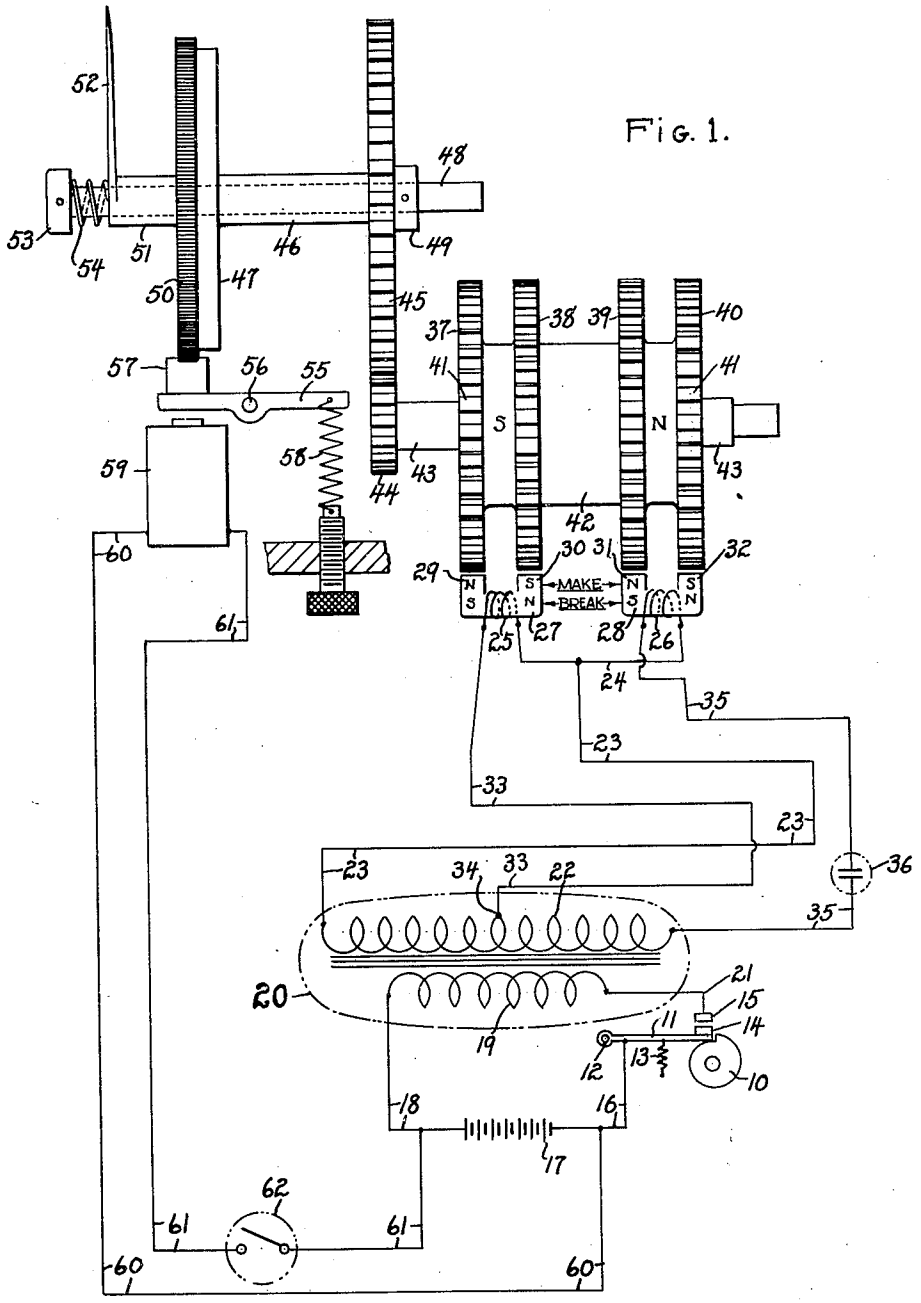
May 16, 1950 W. E. MAXWELL 2,507,798

ELECTRIC IMPULSE COUNTER

Filed May 15, 1945 2 Sheets-Sheet 1

Fig. 1.



INVENTOR
WEYMAN E. MAXWELL
By Seymour, Carter Nichols
ATTORNEYS

May 16, 1950 W. E. MAXWELL 2,507,798

ELECTRIC IMPULSE COUNTER

Filed May 15, 1945 2 Sheets-Sheet 2

Fig. 2.

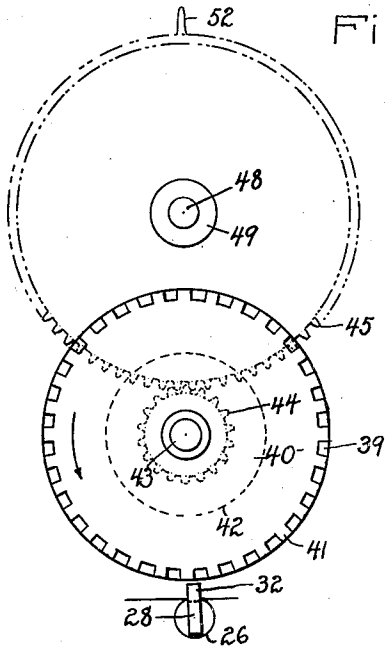
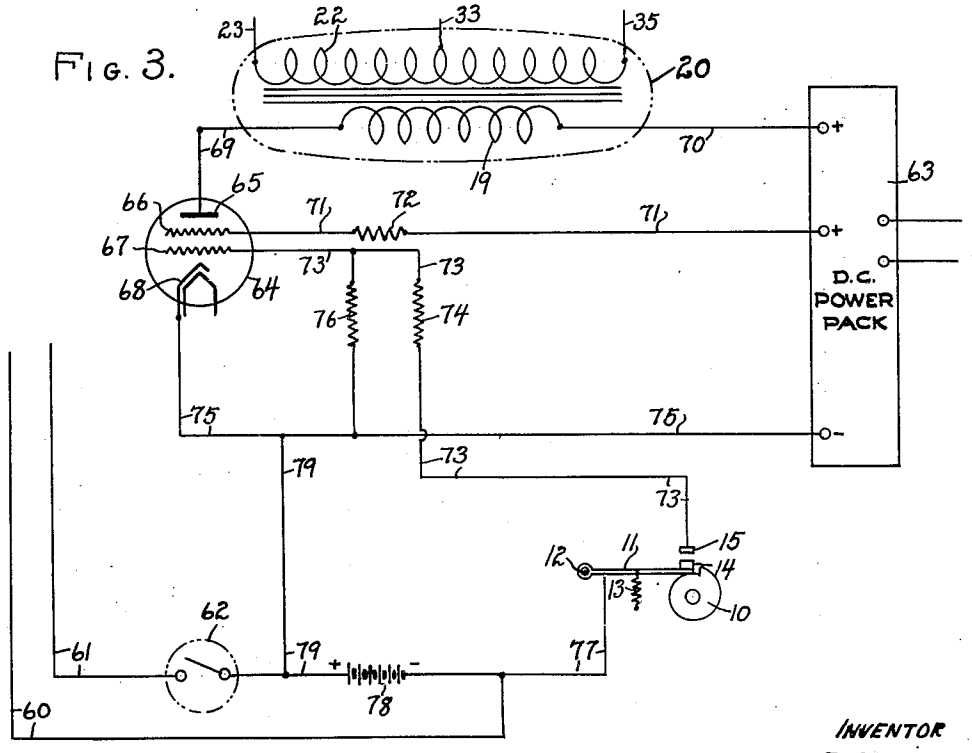


Fig. 3.



INVENTOR
WEYMAN E. MAXWELL
By Seymour, Earle & Nichols
ATTORNEYS

Patented May 16, 1950 2,507,798

UNITED STATES PATENT OFFICE

2,507,798

ELECTRIC-IMPULSE COUNTER

Weyman E. Maxwell, Springfield, Mass., assignor to The Standard Electric Time Company, Springfield, Mass., a corporation of Connecticut

Application May 15, 1945, Serial No. 593,947

4 Claims. (Cl. 235—92)

1

The present invention relates to impulse-counters and relates more particularly to impulse-counters which act to count or indicate electric-impulses such, for instance, as electric-impulses emanating from pickups located adjacent a machine gun to permit the rate of fire thereof to be ascertained, etc., etc.

One of the main objects of the present invention is to provide a superior electric-impulse counter which will provide trouble-free service over long periods of use.

Another object of the present invention is to provide a superior electric-impulse counter which will accurately count or indicate electric-impulses which follow each other at relatively-short intervals, such for instance, as electric-impulses having frequencies of the order of 5000 per minute and up.

With the above and other objects in view, as will appear to those skilled in the art from the present disclosure, this invention includes all features in the said disclosure which are novel over the prior art.

In the accompanying drawings, in which certain modes of carrying out the present invention are shown for illustrative purposes:

Fig. 1 is a schematic view of one form of electric-impulse counter embodying the present invention;

Fig. 2 is an end view of the mechanical portions of the apparatus illustrated in the upper portion of Fig. 1; and

Fig. 3 is a schematic representation of another form of electric pickup-means suitable for energizing the mechanical portions of the apparatus illustrated in the upper portion of Fig. 1 and in Fig. 2.

The apparatus chosen for illustration in Figs. 1 and 2 for purposes of making clear one form of the present invention, includes a control-member or cam 10 which may be rotated by any suitable means which will serve to synchronize the said control-member or cam with the operations which it is desired to count. By way of example, it may be assumed that the control-cam 10 is rotated by internal combustion engine whose R. P. M. it is desired to ascertain. In this connection, however, it may here be pointed out that the control-member or cam 10 or its equivalent, may be operated by a wide variety of contrivances, such for instance as a conveyor belt, a sheet-stacker, etc., etc.

The control-cam 10 is adapted to lift the adjacent end of a switch-arm 11, which is pivoted at a point remote from the control-cam 10, upon

2

a pivot-pin 12 and is normally held in engagement with the periphery of the said control-cam by means of a spring 13. At its free end, the switch-arm 11 carries a contact 14 which is adapted to engage with and disengage from a complemental contact 15, which latter is normally stationary.

The pivotal switch-arm 11 above referred to, is connected by means of a wire 16 to one terminal of a battery 17 or other suitable source of direct current supply. The opposite terminal of the battery 17 is connected by means of a wire 18 to one terminal of the primary-winding 19 of a transformer generally designated by the reference character 20. The opposite terminal of the primary-winding 19 is connected by means of a wire 21 to the stationary contact 15 which complements the movable contact 14 before referred to.

The transformer 20 above referred to, also includes a secondary-winding 22 having one of its terminals connected by means of a wire 23 to a wire 24 which latter serves to interconnect the two adjacent terminals of two energizing-coils respectively designated by the reference characters 25 and 26. The said energizing-coils 25 and 26 respectively encircle and serve to energize U-shaped pole-pieces 27 and 28. The said pole-pieces 27 and 28 are formed of magnetic material such, for instance, as soft iron, silicon steel or the like having low hysteresis characteristics. The pole-piece 27 is formed with two pole-salients respectively designated by the reference characters 29 and 30, while the pole-piece 28 is likewise formed with two pole-salients 31 and 32.

The terminal of the energizing-coil 25 opposite the wire 24, is connected by means of a wire 33 to an intermediate tap 34 of the secondary-winding 22 before referred to. The terminal of the energizing-coil 26 opposite the interconnecting-wire 24, is connected by means of a wire 35 to the right terminal of the secondary-winding 22. Interposed in the wire 35 is a condenser 36 which is designed and adapted to cause the current in the energizing-coil 26 to lead the current in the energizing-coil 25 by substantially 90 electrical degrees, all for purposes as will more fully hereinafter appear.

Returning now to the pole-piece 27, it will be noted by reference to Fig. 1 that the pole-salients 29 and 30 thereof, are respectively located adjacent the peripheries of disk-like rotor-elements 37 and 38. Similarly, the pole-salients 31 and 32 of the pole-piece 28 are respectively located adjacent the peripheries of similar disk-like ro-

tor-elements 39 and 40. The rotor-elements 37 to 40 inclusive just referred to, are preferably formed of soft iron or equivalent non-permanent magnet material and are each formed with an annular series of pole-salients 41.

The rotor-elements 37 and 38 are relatively closely adjacent and are located at one end of a tubular permanent magnet 42 which is preferably formed of Alnico or other suitable permanent magnet material. The end of the permanent magnet 42 opposite the rotor-elements 37 and 38, is in magnetic communication with the rotor-elements 39 and 40. The result of the arrangement just described is that the said permanent magnet coincidentally imparts one fixed polarity to the pole-salients 41 of the rotor-elements 37 and 38 while impressing an opposite permanent polarity to the pole-salients 41 of the rotor-elements 39 and 40.

It will be noted by reference to Fig. 1, that the respective pole-salients 41 of the rotor-elements 37 and 38, are circumferentially displaced with respect to each other a distance equivalent to one full tooth. Similarly, the respective pole-salients of the rotor-elements 39 and 40 are displaced with respect to each other a circumferential distance equal to one full tooth. It will further be noticed that the relative circumferential displacement between the pole-salients 41 of the rotor-element 38 and those of the rotor element 39 is equal to a distance of one-half tooth, all for purposes of insuring the step-by-step rotation of the rotor comprising the parts 37 to 42 inclusive, as the pole-pieces 27 and 28 are energized in sequence in a manner as will hereinafter appear.

The rotor-unit comprising the element 37 to 42 inclusive, is mounted for rotation upon a rotor-shaft 43 adapted to turn in any suitable bearings (not shown) and carries at its forward end a drive-pinion 44. The said drive-pinion meshes into and drives a gear-wheel 45 which is rigidly mounted upon the inner end of a bearing-sleeve 46. The said bearing-sleeve 46 rigidly carries at its forward end a friction coupling-disk 47 for purposes as will presently appear. The unit comprising the gear-wheel 45, bearing-sleeve 46 and coupling-disk 47 is mounted for rotation upon an arbor 48 which carries adjacent its inner end, a stop-collar 49 against the forward face of which bears the inner face of the gear-wheel 45 before referred to.

Mounted upon the forward portion of the arbor 48 in front of the coupling-disk 47 and with freedom for both axial and turning movement on the said arbor, is a unit which comprises a stop-wheel 50 having a serrated periphery, its integral hub 51 and a pointer 52 rigidly carried at the outer end of the said hub. Spaced forwardly of the pointer 52 and rigidly secured to the arbor 48 is a collar 53, against the inner face of which presses the forward end of a helical spring 54. The rear portion of the spring 54 presses against the forward face of the hub 51 and serves to frictionally engage the rear face of the stop-wheel 50 with the forward face of the coupling-disk 47 so as to provide the desired coefficient of friction therebetween.

The friction-coupling just above referred to will under certain conditions, cause the coupling-disk 47 to drive the unit comprising the stop-wheel 50, hub 51 and pointer 52.

For the purpose of releasably restraining the unit comprising the parts 50, 51 and 52 against rotation, a stop-lever 55 is employed. The said stop-lever is formed of magnetic material and is

mounted intermediate its respective opposite ends upon a pivot-pin 56 and carries at its forward end a stop-finger 57 which is adapted to engage with the periphery of the stop-wheel 50 to hold the latter against rotation. The stop-lever 55 is yieldingly urged to turn in the direction required to engage its stop-finger 57 with the periphery of the stop-wheel 50, by means of a helical spring 58.

For the purpose of turning the stop-lever 55 against the tension of its spring 58 to withdraw the stop-finger 57 out of engagement with the serrations on the periphery of the stop-wheel 50, an electromagnet 59 is employed. The said electromagnet is connected by means of two wires 60 and 61 to the wires 16 and 18 respectively, which latter are connected as before described, to the opposite terminals of the battery 17 or other suitable source of direct current. Interposed in the wire 61 is a switch 62 by means of which the energization of the electromagnet 59 may be controlled.

Operation of the apparatus of Figs. 1 and 2

For purposes of description, let it be assumed that the control-cam 10 is being rotated so as to cause (in conjunction with the spring 13) the movable contact 14 to repeatedly engage with and then disengage from the stationary contact 15.

The engagement of the contact 14 with the contact 15 will close the circuit through the primary-winding 19 of the transformer 20 and thereby induce a voltage in the secondary-winding 22. Due to the connections shown, the resultant voltages in the secondary-winding 22 will be impressed upon the energizing-coils 25 and 26 with a relatively-high voltage being applied to the energizing-coil 26 and a relatively-lower voltage being applied to the energizing-coil 25. Due to the fact that the condenser 36 or its equivalent is interposed in the circuit of the energizing-coil 26, the current passing through the said energizing-coil will lead that passing through the complemental energizing-coil 25 by substantially 90 electrical degrees. Thus, in a manner well known in the art, the condenser 36 acts to shift the phase of the current in the circuit of the coil 26 with respect to that in the coil 25.

From the foregoing it will be seen that the energizing-coil 26 will be the first to respond to the transient induced in the secondary-winding 22 as a result of the closing of the contacts 14 and 15. Hence the pole-salient 32 of the pole-piece 28 will attract the adjacent one of the pole-salients 41 of the rotor-element 40 (due to opposite polarities at this instant) while at the same time that the complemental pole-salient 31 is acting to repulse its adjacent pole-salient 41 of the rotor-element 39, with the net result that the rotor-unit will be advanced a distance equivalent to one-half tooth in the direction indicated by the arrow in Fig. 2.

Substantially 90 electrical degrees later the pole-piece 27 will act through its pole-salients 29 and 30 to respectively act on the rotor-elements 37 and 38 to turn the rotor-unit a further distance equivalent to one-half tooth.

From the foregoing it will be seen that one "make" of the contacts 14 and 15 will cause a rotation of the rotor-unit equivalent to one full tooth for what is equivalent to one-half cycle of energization.

Now as the control-cam 10 rotates and permits the contact 14 to separate from the contact 15, the circuit wil be broken and a transient voltage

of reverse polarity will be produced by the magnetic energy stored in the core of the transformer 20. This transient voltage will again cause a leading current to flow through the energizing-coil 26 to again advance the rotor-unit the equivalent of one-half tooth to be followed substantially 90 electrical degrees later by the peak energization of the energizing-coil 25 to thereby further turn the rotor-unit a distance equivalent to another half tooth.

From the foregoing it will be seen that for each cycle of make and break of the contacts 14 and 15, the rotor-unit, considered as a whole, will be rotated a distance equivalent to two teeth.

Under the conditions here being described, the turning of the rotor-unit, as a whole, will act through the rotor-shaft 43, drive-pinion 44, gear-wheel 45 and bearing-sleeve 46 to turn the coupling-disk 47. Due to the fact that at this time the stop-finger 57 is in engagement with the serrated periphery of the stop-wheel 50, the latter will remain stationary while the coupling-disk 47 will slip due to its frictional engagement with the said stop-wheel 50.

For purposes of description let it further be assumed that it is desired to determine the R. P. M. of a prime mover such, for instance, as an airplane engine, in which case the control-cam 10 would be suitably connected to such engine to cause it to revolve in consonance with the engine. Now with the aid of a stop watch or its equivalent, the counting cycle may be started by closing the switch 62. Upon closing the switch 62 the electromagnet 59 will be energized to thereby attract the stop-lever 55 and turn the same in a counterclockwise direction about the pivot-pin 56, to thus withdraw the stop-finger 57 from engagement with the periphery of the stop-wheel 50. When thus released, the stop-wheel 50 will be substantially instantaneously started into motion by the friction of the coupling-disk 47 and will, of course, coincidentally turn the pointer 52.

As soon as the counting cycle is concluded, the opening of the switch 62 will deenergize the electromagnet 59 thereby permitting the spring 58 to act through the stop-lever 55 to re-engage the stop-finger 57 with the serrated periphery of the stop-wheel 50 to substantially instantaneously check the further movement thereof despite the friction drive of the coupling-disk 47. In some installations the switch 62 or its equivalent may be automatically operated so as to close and open at predetermined intervals.

In instances where it is desired to employ the electric-impulse counter, above described, for purposes of counting sheets as the same are stacked in a pile, the control-cam 10 may be suitably connected to the stacker so that the said control-cam can turn one complete revolution for the stacking of each single sheet. During the counting period the switch 62 would remain closed so that the pointer 52 may be turned to record each sheet so stacked.

By employing a split-phase self-starting motor-structure of the permanently-magnetized rotor type capable of having the movement of its rotor take place in a step-by-step manner, in conjunction with a transformer or equivalent inductance, both the effects of the make and the break of the circuit are utilized to operate such a motor. Thus, accurate counting of electric impulses may be achieved even when such impulses follow each other at a rate greatly in excess of five thousand impulses per minute.

The apparatus of Fig. 3

The apparatus illustrated in Fig. 3 is designed and adapted to effect the energization of a self-starting synchronous electric motor like that shown in the upper portion of Fig. 1 in lieu of the portion of the apparatus shown in the lower portion of the said figure.

The apparatus illustrated in Fig. 3 includes the transformer 20, the switch-arm 11 and associated parts, as well as the switch 62 for controlling the energization of an electromagnet like 59. In addition, the apparatus includes a direct current power-pack 63, a power-amplifying tube 64, which latter in the instance shown is a tetrode-tube comprising a plate 65, a screen-grid 66, a control-grid 67 and a cathode 68.

The plate 65 of the tube 64 is connected by means of a wire 69 to one terminal of the primary-winding 19 of the transformer 20. The remaining terminal of the said primary-winding 19 is connected by means of a wire 70 to the higher-value plus terminal of the power-pack 63. The screen-grid 66 is connected by means of a wire 71 to a plus terminal of the power-pack, which plus terminal has a voltage materially less than the voltage of the plus terminal to which the wire 70 is connected. Interposed in the wire 71 is a resistor 72.

The control-grid 67 of the tube 64 is connected by means of a wire 73 to the stationary contact 15 which is engaged by the contact 14 in a manner previously described in connection with the description of Figs. 1 and 2. Interposed in the wire 73 is a resistor 74, as shown. The cathode 68 of the tube 64 is connected by means of a wire 75 to the negative terminal of the power-pack 63. Connected between the wires 73 and 75 is a resistor 76 which is adapted to bias the control-grid 67 at the potential of the cathode 68 under conditions of no input signal, i. e., when the contact 14 is out of engagement with the contact 15.

The switch-arm 11 is connected by means of a wire 77 to the negative terminal of a control-battery 78. The positive terminal of the battery 78 is connected by means of a wire 79 to the wire 75 leading to the cathode 68 of the tube 64. Connected into the wire 79 is the wire 61 before referred to, which leads to an electromagnet such as 59 of Fig. 1, and in which wire is interposed the switch 62 before referred to. The wire 60 referred to in the description of the apparatus of Figs. 1 and 2, is connected into the wire 77 and hence to the negative terminal of the control-battery 78, as shown at the lower portion of Fig. 3. The wire 61 is connected through the switch 62 to the wire 79 and also to the positive terminal of the control-battery 78.

The functioning of the apparatus of Fig. 3

When during turning movement of the control-cam 10, the contact 14 is brought into engagement with the contact 15, a potential will be thereby applied to the control-grid 67, which potential is negative with respect to the voltage which at this time is being applied to the cathode 68. This action will result in the plate-current falling to zero thus deenergizing the primary-winding 19 of the transformer 20 thus causing the energy stored in the core of the said transformer to act in the manner previously described in connection with the description of the apparatus of Figs. 1 and 2, to effect the turning of the rotor.

As soon, in the revolution of the control-cam, as the contact 14 is disengaged from the contact

15, the respective potentials applied to the control-grid 67 and cathode 68 will, by virtue of the resistor 76, achieve the same value, thereby permitting the flow of plate-current and the energization of the primary-winding 19.

As the plate-current flows as above described, and the primary-winding 19 is energized, the secondary-winding 22 will produce and induce voltage which as it rises will affect the synchronous electric motor in the manner previously described in connection with the apparatus of Figs. 1 and 2.

From the foregoing it will be seen that the apparatus illustrated in Fig. 3 acts basically in the same manner as that illustrated in the lower portion of Fig. 1, to utilize both the build-up and decline of magnetic flux to effect the step-by-step rotation of a self-starting synchronous electric motor of the general type illustrated in Figs. 1 and 2.

The mechanically-operated switch mechanism including the parts 10 to 15 inclusive above described, may obviously be replaced by any other suitable apparatus which will provide the impulses needed to cause the apparatus to function, such, for instance, as a photoelectric cell, microphone, capacity relay or the like.

The invention may be carried out in other specific ways than those herein set forth without departing from the spirit and essential characteristics of the invention, and the present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive, and all changes coming within the meaning and equivalency range of the appended claims are intended to be embraced therein.

I claim:

1. In an electric-impulse counter for counting direct-current electric-impulses of a wide range of frequencies, the combination with a split-phase self-starting synchronous electric motor of the type having a rotor provided with at least two toothed rotor-elements permanently magnetized to opposite signs respectively, and a stator-structure including a first energizing-coil magnetically cooperating with one of the said toothed rotor-elements to effect the step-by-step rotation of the rotor and a second energizing-coil magnetically cooperating with the other of the said toothed rotor-elements to effect the step-by-step rotation of the rotor; of a transformer having a primary and a secondary, the said secondary having a low-voltage tap and a high-voltage tap; means electrically connecting the said first energizing-coil with the low-voltage tap of the said secondary; means electrically connecting the said second energizing-coil to the high-voltage tap of the said secondary; phase-splitting means associated with the said second energizing-coil to cause the magnetic flux developed thereby to assume an out-of-phase relationship with respect to the magnetic flux developed by the said first energizing - coil; direct - current interrupting means alternately energizing and deenergizing the primary of the said transformer with direct current to develop transients in the said secondary of alternately-opposite polarities; and indicating-means driven by the rotor of the said motor to count the cycles of alternate energizing and deenergizing of the said primary.

2. In an electric-impulse counter for counting direct-current electric-impulses of a wide range of frequencies, the combination with a split-phase self-starting synchronous electric motor of the type having a rotor provided with

two pairs of toothed rotor-elements permanently magnetized to opposite signs respectively, and a stator-structure including a first energizing-coil magnetically cooperating with one of the said pairs of toothed rotor-elements to effect the step-by-step rotation of the rotor and a second energizing-coil magnetically cooperating with the other of the said pairs of toothed rotor-elements to effect the step-by-step rotation of the rotor; of a transformer having a primary and a secondary, the said secondary having a low-voltage tap and a high-voltage tap; means electrically connecting the said first energizing-coil with the low-voltage tap of the said secondary; means electrically connecting the said second energizing-coil to the high-voltage tap of the said secondary; phase-splitting means associated with the said second energizing-coil to cause the magnetic flux developed thereby to assume an out-of-phase relationship with respect to the magnetic flux developed by the said first energizing-coil; direct-current interrupting means alternately energizing and deenergizing the primary of the said transformer with direct current to develop transients in the said secondary of alternately-opposite polarities; and indicating-means driven by the rotor of the said motor to count the cycles of alternate energizing and deenergizing of the said primary.

3. In an electric-impulse counter for counting direct-current electric-impulses of a wide range of frequencies, the combination with a split-phase self-starting synchronous electric motor of the type having a rotor provided with at least two toothed rotor-elements permanently magnetized to opposite signs respectively, and a stator-structure including a first energizing-coil magnetically cooperating with one of the two said toothed rotor-elements to effect the step-by-step rotation of the rotor and a second energizing-coil magnetically cooperating with the other of the two said toothed rotor-elements to effect the step-by-step rotation of the rotor; of a transformer having a primary and a secondary, the said secondary having a low-voltage tap and a high-voltage tap; means electrically connecting the low-voltage tap of the said secondary with the said first energizing-coil; means electrically connecting the high-voltage tap of the said secondary with the said second energizing-coil; phase-splitting means interposed in the means electrically connecting the said high-voltage tap to the said second energizing-coil; direct-current interrupting means alternately energizing and deenergizing the primary of the said transformer with direct-current to develop transients in the said secondary of alternately-opposite polarities; and indicating-means driven by the rotor of the said motor and constructed and arranged to count the cycles of alternate energizing and deenergizing of the primary of the said transformer.

4. In an electric-impulse counter for counting direct-current electric-impulses of a wide range of frequencies, the combination with a split-phase self-starting synchronous electric motor of the type having a rotor provided with two pairs of toothed rotor-elements permanently magnetized to opposite signs respectively, and a stator-structure including a first energizing-coil magnetically cooperating with one of the two said pairs of toothed rotor-elements to effect the step-by-step rotation of the rotor and a second energizing-coil magnetically cooperating with the other of said pairs of toothed rotor-elements to effect the step-by-step rotation of the rotor; of

a transformer having a primary and a secondary, the said secondary having a low-voltage tap and a high-voltage tap; means electrically connecting the low-voltage tap of the said secondary with the said first energizing-coil; means electrically connecting the high-voltage tap of the said secondary with the said second energizing-coil; phase-splitting means interposed in the means electrically connecting the said high-voltage tap to the said second energizing-coil; direct-current interrupting means alternately energizing and deenergizing the primary of the said transformer with direct-current to develop transients in the said secondary of alternately-opposite polarities; and indicating-means driven by the rotor of the said motor and constructed and arranged to count the cycles of alternate energizing and deenergizing of the primary of the said transformer.

WEYMAN E. MAXWELL.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
711,635	Lavens	Oct. 21, 1902
1,468,490	Merrick	Sept. 18, 1923
1,812,187	Ackerly	June 30, 1931
1,925,882	Smith	Sept. 5, 1933
2,122,307	Welch	June 28, 1938
2,249,029	Mullenheim	July 15, 1941

FOREIGN PATENTS

Number	Country	Date
28,539	Great Britain	1902